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Widening the view: the relevance of multi-decadal wind generation variability

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The international community has agreed upon ambitious targets for climate change mitigation. Both temperature targets of the Paris Agreement require net zero carbon emissions within a few decades. While costs for renewables have declined substantially, the design and operation of highly renewable power systems is challenged by generation variability.

The quantification of generation variability is often based on modern reanalysis and this approach is incapable to capture low-frequency variability. We demonstrate that wind power generation features significant multi-decadal variability. The assessment is based on current 20th century reanalyses (20CRv2c, ERA20C, CERA20C) and their inconsistencies regarding trends will be discussed. We focus on Germany as it represents a major economy and currently generates around one fifths of its electricity from wind. The strongest signal is found in the winter-to-summer generation ratio (i.e. seasonality) with a max-min amplitude of 30% of the long-term mean and a period of around 35 years. Statistically significant modes of variability with periods of 25 to 50 years are found in all seasons except winter. In winter, there is a good connection with low-frequency variability of the North-Atlantic Oscillation. Our results imply that power system design has to be considered a perpetual process that follows multi-decadal climate variability.